

N O T I C E

THIS DOCUMENT HAS BEEN REPRODUCED FROM
MICROFICHE. ALTHOUGH IT IS RECOGNIZED THAT
CERTAIN PORTIONS ARE ILLEGIBLE, IT IS BEING RELEASED
IN THE INTEREST OF MAKING AVAILABLE AS MUCH
INFORMATION AS POSSIBLE

DOE/NASA/2674-11
NASA TM-81499

ENGINEERING TEST FACILITY DESIGN DEFINITION

(NASA-TM-81499) ENGINEERING TEST FACILITY
DESIGN DEFINITION (NASA) 16 p HC A02/MF A01
CSCL 10A

N80-27799

Unclas
G3/44 28081

R.W. Bercaw and G.R. Seikel
National Aeronautics and Space Administration
Lewis Research Center

Work performed for
U.S. DEPARTMENT OF ENERGY
Energy Technology
Magnetohydrodynamics Division



Prepared for
Seventh International Conference on Magnetohydrodynamic
Electric Power Generation sponsored by the Symposia on the
Engineering Aspects of Magnetohydrodynamics, Inc.
Cambridge, Massachusetts, June 16-20, 1980

NOTICE

This report was prepared to document work sponsored by the United States Government. Neither the United States nor its agent, the United States Department of Energy, nor any Federal employees, nor any of their contractors, subcontractors or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

DOE/NASA/2674-11
NASA TM-81499

ENGINEERING TEST FACILITY DESIGN DEFINITION

R.W. Bercaw and G.R. Seikel
National Aeronautics and Space Administration
Lewis Research Center
Cleveland, Ohio 44135

Performed for
U.S. DEPARTMENT OF ENERGY
Energy Technology
Magnetohydrodynamics Division
Washington, D.C. 20545
Under Interagency Agreement EF-77-A-01-2674

Seventh International Conference on Magnetohydrodynamic
Electric Power Generation sponsored by the Symposia on the
Engineering Aspects of Magnetohydrodynamics, Inc.
Cambridge, Massachusetts, June 16-20, 1980

ENGINEERING TEST FACILITY DESIGN DEFINITION**

R. W. Bercaw and G. R. Seikel

NASA Lewis Research Center

Cleveland, Ohio 44135

Introduction

E-436 The Engineering Test Facility (ETF) is the major focus of the Department of Energy (DOE) MHD Program to facilitate commercialization and to demonstrate the commercial operability of MHD/steam electric power.¹ MHD offers the potential of an environmentally acceptable approach toward utilizing the United States' abundant coal resources to produce electric power at very high efficiency and attractive cost.

The construction and operation of the ETF is viewed as the second phase of the DOE MHD Program. The initial phase is the engineering development of essential components and systems and the preparation of a conceptual design of the ETF. The Director, Office of MHD, has specified the general definition of the ETF shown in Table 1.

TABLE 1

MHD ENGINEERING TEST FACILITY (ETF)

GOAL:

- o Demonstrate commercial feasibility of MHD power

DEFINITION:

- o Prototype of initial commercial plant
- o Size: Nominal 200 MW_e
- o Surpass all environmental regulations
- o Performance to meet or surpass existing utility standards for
 - Fuel, maintenance, and operating costs
 - Plant availability

** Prepared under NASA-DOE Interagency Agreement No. EF-77-A-01-2674

--Load following characteristics

--Durability

--Safety

This paper describes the current design concept conforming to the general definition, the basis for its selection, and the process which will be followed in further defining and updating the conceptual design. The design of the ETF must be a sub-scale prototype of an attractive commercial plant and also be closely coordinated with the Engineering Development Program. It must evolve with time to incorporate the continuing progress in both the systems engineering studies of commercial plants and the engineering development of components and systems. However, many issues have been resolved in the last year and the design concept has matured to the point that radical changes are unlikely.

The selected power level (nominal 200 MW_e) places the ETF within the range of plant sizes now being ordered by electric utility companies, yet does not make it so large that funding and scale-up are excessive. It will be within a reasonable scaling factor of 2-3 of the size plant currently most popular with the utilities (400-600 MW_e) and also the size where MHD is expected to become cost competitive. The ETF will be large enough to be commercially competitive with regards to performance and operating costs, but it can not be considered a commercial plant because the added benefits over a conventional fossil plant would not justify the additional capital expenditure. Government funding would thus be required to supply the bulk of the capital for ETF construction, but after an initial testing phase it is anticipated that ETF could be operated profitably by a Utility. The latter factor is significant because it minimizes the burden on the Government of paying the fuel charges involved in performing life tests and gaining adequate operating experience. The size of the ETF is approximately 50-80% larger than that investigated by contractors in the initial ETF Design Studies.^{2,3} To reduce the risk associated with scaling to ETF from the engineering basis demonstrated in CDIF, DOE is assessing in parallel the requirements for increasing the thermal power level of CDIF from 50 MW_t up to as high as 100 MW_t.

ETF Program Alternatives

The baseline concept for ETF is that it will be a "stand alone" completely new plant, but there are two alternative options. The ETF topping cycle could be added to an existing fossil fired steam plant as a "retrofit" or it could be used to provide a portion of the steam needed to power the turbines of a new 500-800 MW_e coal fired plant. The relative merits of these implementation options, which have many site-specific aspects, are being evaluated by parametrically investigating the integration of the ETF topping cycle with representative steam plants of various types. To date it has been established that the only credible way of integrating a

MHD topping cycle with a stand-alone steam plant is through a relatively uncomplicated steam and water interface. The more complex option, in which the MHD exhaust gasses exiting from the diffuser are directed into an existing boiler, has been found to be impractical.⁴ The design effort expended on the baseline option is therefore almost entirely applicable to the other options.

Target Commercial Plant

The ETF can demonstrate the commercial viability of MHD only if it is a subscale prototype of an attractive commercial plant which will be referred to in this paper as the target commercial plant.

The Energy Conversion Alternatives Study (ECAS)⁵ was a comparative evaluation of the long range potential of a variety of advanced coal-fired power plant concepts. It found that open-cycle MHD-topped steam power plants had one of the highest efficiencies and lowest costs of electricity of any of the concepts studied. In particular, it found that a coal-fired open-cycle MHD/steam power plant could achieve a coal-to-busbar efficiency approaching 50%, which is about a 50% improvement over steam plants meeting the current environmental standards. Two preliminary cost-benefit market-penetration studies, performed for the Electric Power Research Institute⁶ by Westinghouse and General Electric, compared open cycle MHD with other advanced coal cycles, light water reactors and conventional coal-fired steam plants. The results indicated that MHD has the potential for taking over a major portion of the new baseload market.

The ECAS study demonstrated the advantages of mature MHD plants, but the plant design required the simultaneous development of a number of advanced technologies prior to its construction. Because the early commercialization of MHD is required to maximize its benefits to the Nation, it was essential to identify attractive plant designs which would require only technology available in the 1980's. Two separate studies were initiated to investigate plants based on alternatives to the direct-fired high temperature air heater (HTAH) which was judged to be the most difficult technology to demonstrate. The studies were based on the use of air separation plants or HTAHs fired with clean fuel, both of which are in wide use in the steel industry. The three ETF Design Study contracts performed by Avco², General Electric³, and Westinghouse⁷ investigated plant designs based on these concepts and focused on identifying attractive designs for the MHD systems (In this paper we will use the term "MHD systems" to mean the power train, magnet, the heat and seed recovery system (HR/SR) and the seed reprocessing plant). The studies also provided plant configurations and layouts, and identified a variety of issues. A comparative analysis of the results by the Government succeeded in resolving a number of the issues. For example, it reduced the proposed design concepts for the heat and seed recovery system to those derived from the recovery furnace technology used in the Kraft paper industry. It also highlighted the need for low heat loss in the MHD combustor as a prerequisite for economically achieving the necessary flame temperature. Single-stage combustors have an advantage in this regard, but

two stage combustors were not eliminated because of other design considerations and unresolved issues. The studies were not able to identify a near-term coal gasifier that was suitable for a first stage of the combustor and this concept has subsequently been dropped.

A separate parallel study, referred to as the "Studies of Potential Early Commercial MHD (SPEC) power plants", was initiated to evaluate alternative plant configurations and was largely based on scaled up revisions of the MHD systems designs identified in the ETF Design Studies. The ground rules specified that the fuel be restricted to coal and that the plants meet the latest New Source Pollution Standards. The initial Parametric phase of the studies (PSPEC), under two parallel contracts,^{8,9} investigated plants based on three different "state-of-the-art" oxidizer preparation systems as alternatives to direct-fired HTAH:

1. A "conservative" HTAH indirectly fired with low BTU gas produced in a commercially available coal gasifier,
2. A somewhat more advanced HTAH indirectly fired with low BTU gas produced in an advanced coal gasifier (or using direct coal combustion),
3. Direct recuperative heating to an intermediate temperature of air enriched with oxygen from an on-site air separation unit.

The contractors prepared a large number of parametric variations on these base cases in order to evaluate different combustors and other plant design options. The results of these studies, which are presented in the paper "A Summary and Evaluation of PSPEC" by Staiger and Abbott¹⁰, indicate that there are a variety of designs which could provide efficiencies of about 45% and reasonable cost of electricity.

Oxidizer Preparation System

Figure 1 compares the PSPEC estimates of the efficiency and cost of electricity for plants based on the different oxidizer preparation systems. Both contractors' studies found the plants using oxygen enrichment to be more efficient and to have a lower cost of electricity than the plants using the state-of-the-art gasifier/HTAH combination. The Avco study also found them to be more attractive than the plants using the advanced gasifier/HTAH combination. The General Electric study did not, but very few parametric cases based on oxygen enrichment were studied and we believe that oxygen enrichment would appear more attractive if additional cases were evaluated. Because of these results, two of the ETF Design Study contractors (Avco and General Electric) were directed to incorporate oxygen enrichment in their ETF designs.^{2,3} The results were very similar to each other and confirmed the PSPEC findings. Oxygen enrichment is therefore the preferred system on the basis of cost and efficiency but other factors such as availability, reliability, system complexity, safety, and reducing the requirements for additional development also favor this selection.

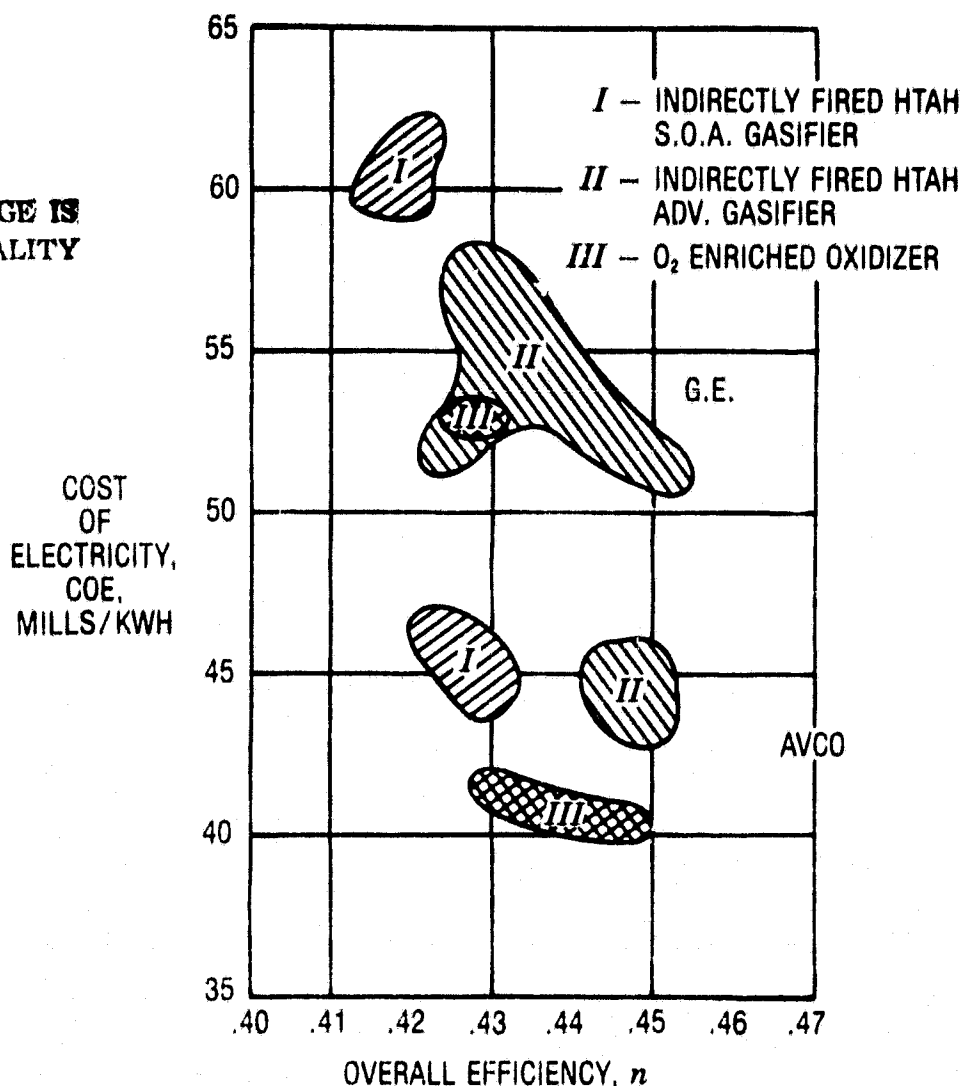
Essentially all of the oxygen technology required to build the ETF is commercially available. Numerous self-contained air separation units which produce pure oxygen are in use and have established a history of safe, reliable and low overhead operation. A study¹¹ conducted by Lotepro, Inc., a subsidiary of the Linde AG Corporation of West Germany, and managed by Gilbert Associates and NASA Lewis, found that impure oxygen could be produced for 208 kWh/ equivalent ton of pure oxygen (this value was used

FIGURE 1

Summary of PSPEC Results

COMPARISON OF ALTERNATIVE OXIDIZER SYSTEMS

ORIGINAL PAGE IS
OF POOR QUALITY



in the PSPEC study). The study was based on technology used in a 60% purity oxygen plant, built by Linde AG for the Thyssen Steel Works in West Germany,

which consumes 224 kWh per equivalent ton of pure oxygen. The plant has been operating reliably since 1972. A second more extensive study is being conducted by Lotepro and Linde AG for NASA Lewis which indicates that the production cost of 60-70% pure oxygen can be lowered to approximately 190 kWh per equivalent ton of pure oxygen. The study has also reviewed the status of compressors for oxygen service and found that adequate compressors are commercially available.

The status of the required gasifier and HTAH technology is much less satisfactory. The PSPEC studies found that the combined requirements of using coal as a fuel and meeting the latest New Source Pollution Standards considerably, increased the complexity of the system over the oil-fired HTAH designs described in the ETF Design Study.^{2,3} Even the state-of-the-art system described in PSPEC case 1 assumed considerable extensions to the current applied design practice in the steel industry. In particular the PSPEC study assumed a higher air temperature (2700F vs. 2450F), smaller holes in the checkers to achieve higher heat transfer rates per unit mass, and a higher tar content in the coal gas used to fire the heaters. It has been estimated that the current technology base is adequate to make these extensions, but there has been no demonstration made of the operation of an integrated system and it is estimated that such a demonstration would be expensive and could possibly add several years to the ETF schedule. The funds for it would have to be found from those available for other portions of the MHD program. It is estimated that the adoption of the gasifier/HTAH combination would result in significantly more start up and operational problems than the adoption of oxygen enrichment. A failure mode and effects analysis of the Avco ETF design¹² found that many of the potential failure modes of the HTAH system would lead to severe consequences. Gasifiers and HTAHs are not noted for low maintenance and Westinghouse, in a study¹³ for EPRI, estimated a significantly lower overall plant availability for a MHD plant based on their use than for a MHD plant based on oxygen enrichment. In particular the study found that for the same plant availability, the requirement on channel lifetime for an oxygen enriched plant could be lowered by 25%. Both types of oxidizer preparation systems use metallic recuperative heat exchangers in the HR/SR system. There is some design uncertainty involved in heating of oxygen enriched air, but it is believed that the dominant technical issue is the corrosion caused by the seed on the outside of the heat transfer surface.

Based on the assessments summarized in Table 2, a decision was made by the Director of the Office of MHD in August 1979 to select the oxygen enrichment option for use in the ETF and the target commercial plant. It was also decided to continue work on the direct fired HTAH technology required for second generation plants because of the large improvements anticipated from their use.

TABLE 2

SELECTION OF OXIDIZER SYSTEM

GUIDELINE: Only state-of-the-art systems shall be considered for ETF

OPTIONS:

1. Oxygen enrichment with 1100F recuperative preheater
2. Separately-fired 2500-2700F HTAH, S.O.A. gasifier, & cleanup

THE OXYGEN ENRICHMENT SYSTEM HAS BEEN SELECTED BECAUSE IT HAS:

1. Lower capital cost & cost of electricity - PSPEC & ETF studies
2. Higher performance - PSPEC and ETF studies
3. No additional pre-ETF development
4. Less system complexity and O&M expense
5. Higher availability - EPRI study, Westinghouse estimated a 25% reduction in the channel lifetime requirements to achieve same plant availability
6. Safety & Reliability - Westinghouse failure and effects mode analysis of Avco ETF design having oil-fired HTAH identified many possible operational problems with severe consequences

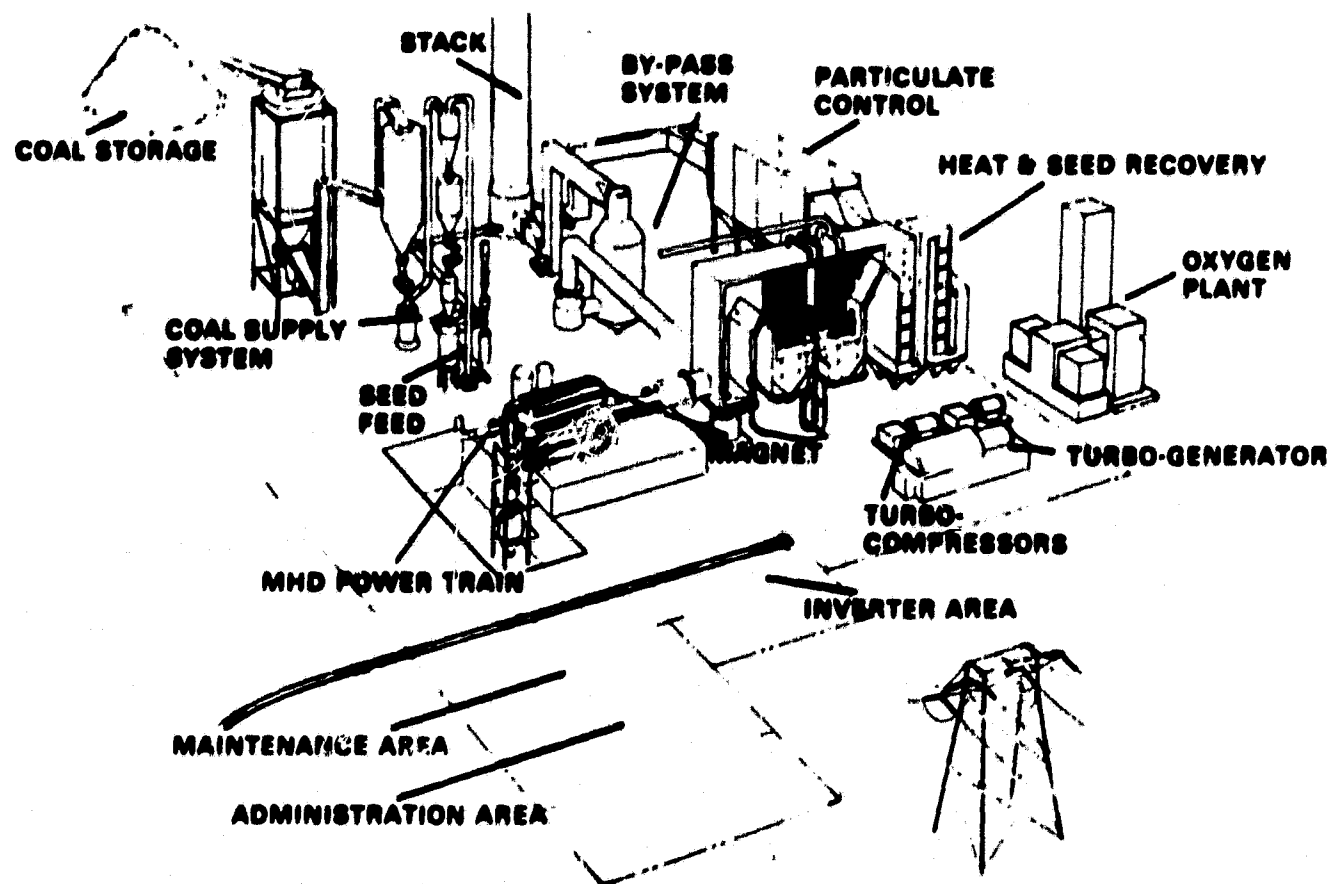
DIRECTLY-FIRED HTAH BASED PLANT IS STILL THE MOST ATTRACTIVE FOR SECOND GENERATION PLANTS.

ETF Design

The oxygen-enriched ETF designs prepared by Avco² and General Electric³ in the follow-on phase of the ETF design studies are quite similar. A pictorial view of the Avco 300 MW_t design for ETF is shown in Figure 2. The results of these studies were combined with the programmatic decisions discussed earlier to produce the Basic ETF Requirements¹⁴ shown in Table 3.

The Basic Requirements specify Montana coal ash carryover at less than 35%, but engineering studies will be conducted to evaluate the modifications which would be required to adapt the design to Illinois #6 and to the use of combustors having up to 100% slag carryover. The seed mixture was adjusted to match the sulfur content of the coal so that all the sulfur reacts with the potassium, but also minimizes the quantity of seed reprocessed. The reference values on the flows and heat rates were taken from thermodynamic analyses of a 50% scale-up of the Avco design.

MHD ENGINEERING TEST FACILITY



CS-80-888

These requirements were used as the starting point for the drafting of a DOE/NASA Design Requirements (DRD). As described in Table 4, the DRD will be the controlling document for design and procurement of the ETF. It also translates the ETF requirements into requirements on its constituent systems and will be used to insure that the various system designs provided by the DOE Engineering Development Programs are mutually compatible and fulfill their functions in the ETF. Consequently, it will be a very carefully controlled document and changes to it will only be made upon the approval of all of the cognizant Program managers.

TABLE 3

BASIC REQUIREMENTS

INPUTS:

FUEL: Montana Rosebud Coal

H₂O - 5% + 2%, Ash - 12% Max, Sulfur - 1% Max

HHV - 10762 Btu/lb. Typical

Mass Flow - 150,000 lb/hr

Ash Carry Over - less than 35%

OXIDANT: Oxygen Enriched Air

Oxygen - 35% vol ref., Temp - 1100F ref

Mass Flow - 625,000 lb/hr ref

SEED: K₂CO₃ - K₂SO₄ Mixture

Potassium 1% ref. 1.25 Max

K₂CO₃/K₂SO₄ weight ratio - 70/30 ref,
45/55 min

Mass flow - 15,500 lb/hr ref

ENERGY OUTPUTS: Reference

MHD Generator - 85 MW_e

Steam Generator and Economizer - 260 MW_t

Air Heaters - Mid & Low Temp - 34 MW_t & 6 MW_t

Net Plant Output - 169 MW_e

NET PLANT EFFICIENCY: 37% Reference

LOAD RANGE: 75% to 110% of the Plant Reference
Power Output

DURABILITY/RELIABILITY: Operation at a 75%
availability level over a
period of at least one year

TABLE 4

ENGINEERING TEST FACILITY
DESIGN REQUIREMENTS DOCUMENT

APPLICATION: Controlling document for the acquisition of the ETF

- o Assures mutual compatability of systems under engineering development and between them and the facility
- o Controls preparation of conceptual designs
- o Basis for procurement of engineering and construction

SCOPE: Provides design and performance requirements for the ETF

- o Objectives and definition of the ETF
- o Plant description
- o Basic requirements
- o Other plant performance and operating requirements
- o System functions and requirements
- o Reference mass flows and energy balances

APPROVAL:

- o Through the Director, Office of MHD (DOE)

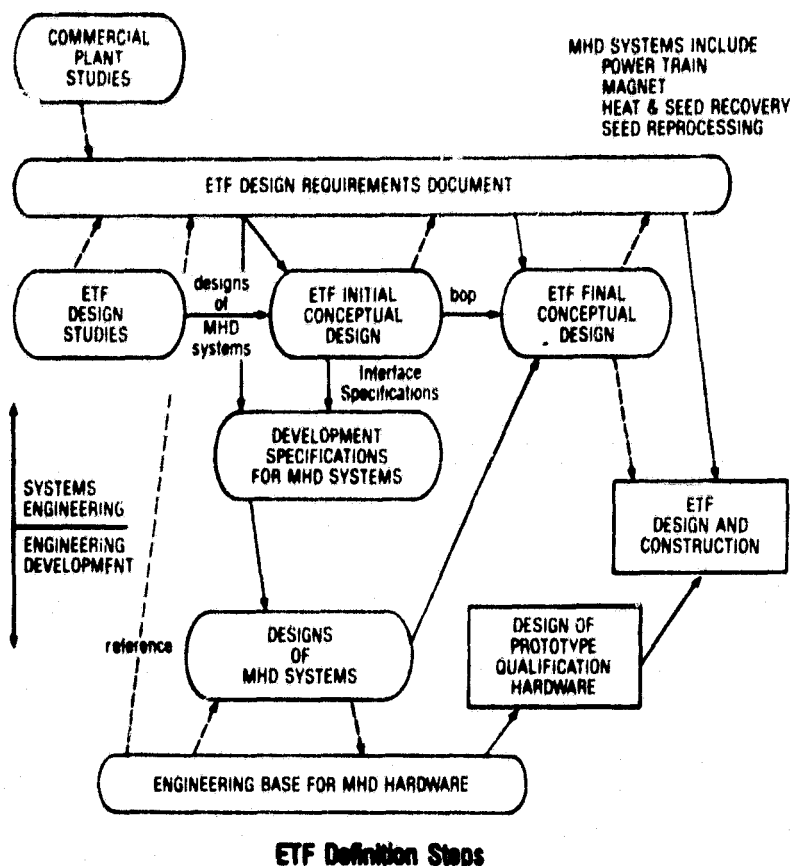
NASA LeRC will prepare at least two generations of conceptual designs of the ETF with the assistance of DOE/Chicago Operations Regional Office (CORO), Argonne National Laboratory, National Magnet Laboratory, and Gilbert Associates, Inc. The designs will be prepared in accordance with the DRD and will serve to validate it by demonstrating that the requirements contained in it are self-consistent and can be obtained if the specified system functions and requirements are achieved by the Engineering Development Program. The designs integrate the results of analytical system studies and analyses of alternative concepts with available designs of the MHD systems. The designs are only representative of the plant which will actually be built, but they provide the basis for the engineering, cost, and schedule estimates used in the ETF Project. They also serve as reference designs for evaluating technical or programmatic alternatives and for studying dynamics, safety, controls, etc.

Figure 3 is illustrative of the definition process which will end in the design and construction of the ETF; the actual process, being subject to approval and revision, is beyond the scope of this paper. The initial plant design will be prepared by Gilbert Associates, Inc. using currently available designs for the MHD systems; i.e. scaled up versions of the designs prepared in the ETF Design Studies or other study contracts. These designs were not prepared in accordance with the ETF DRD, nor were they subject to approval by the DOE Engineering Development Program Managers. Therefore, the initial ETF Conceptual Design will not necessarily be fully consistent with the DOE MHD Engineering Development Program, but it will provide the first design of the balance of the plant which is consistent with the approved design requirements and will define tentative interfaces

between the systems comprising the plant. It will thus identify the technical issues which involve more than one of the MHD systems and provide a vehicle for resolving conflicting requirements between the Development Programs.

FIGURE 3

ORIGINAL PAGE IS
OF POOR QUALITY



The second conceptual design will be based on an updated DRD and MHD-systems designs which are consistent with the Engineering Development Program. This will be accomplished by using designs which are prepared either by or under the direction of the major MHD Field Centers participating in the Engineering Development Program in accordance with ETF Development Specifications (DS). The ETF DS are composites of the system functions and performance requirements from the DRD, mechanical and other interface guidelines derived from the specifications used in preparing the initial ETF Conceptual Design, and guidelines for optimizing performance. The intent is that the DS will constrain the resulting designs enough to allow the ETF to meet its objectives and to assure compatibility between the

systems, but still provide the freedom needed by the designers to provide improved alternatives to the initial design concepts. It is anticipated that there will be some adjustments of the specifications to permit compromise solutions to technical problems, and that the ETF design will evolve to meet or exceed the overall ETF requirements.

It is the goal of the Programs for the Advanced Power Train to provide qualifications of the engineering data base for the design, construction, and operation of MHD systems for the ETF. The preparation of designs in accordance to the ETF ORD and DS by the principals in these Programs followed by the successful integration of the designs into the ETF Conceptual Designs, provides the mechanism for assuring the adequacy of the designs of the prototype qualification hardware.

It is currently envisioned that the preliminary design, final design, construction, check out, and start up of the ETF will be competitively procured. The ORD will be the controlling document; the final Conceptual Design and designs of the qualification prototypes will be used as design references.

References

1. Assistant Secretary for Energy Technology, U. S. Department of Energy. "Fossil Energy Program Summary Document", DOE/ET-0087, 1979.
2. F. Becker, et. al., "Conceptual Design of an MHD/Steam Power Plant of Pilot Scale (ETF) and Preliminary Analyses of Early Commercial MHD Power Plants", 18th Symposium on Engineering Aspects of MHD, Butte, Montana, June 1979.
Avco Everett Research Laboratory, Inc., "Engineering Test Facility Conceptual Design" Final Reports, DOE/FE-2624-2, June 1979 and DOE/FE-2624-3, November 1979.
3. C. H. Marston, et.al., "A 250 MW_t MHD Engineering Test Facility (ETF) System Design", 18th Symposium on Engineering Aspects of MHD, Butte, Montana, June 1979.
General Electric Co., "MHD-ETF Program Final Report", DOE/FE 2613-6, March 1978 and DOE/FE 2613-7, October 1979.
4. J. Cutting et. al., "Retrofit Applications of MHD Topping Cycles to Steam Power Plants, 18th Symposium on Engineering Aspects of MHD, Butte, Montana, June 1979.
5. "Evaluation of Phase 2 Conceptual Designs and Implementation Assessment Resulting From The Energy Conversion Alternatives Study (ECAS)", NASA/TM X-73515, April 1977, and references therein.
6. "Operational Analysis of MHD", Progress Status Reports January 1979-March 1978, Westinghouse Electric Corporation, EPRI Contract No. RP-634-1.
General Electric Company, "Comparative Study and Evaluation of Advanced Cycle Systems" Final Report, EPRI/AF-664, February 1978.
7. Westinghouse Electric Corp., "MHD ETF Conceptual Design" Final Report DOE/FE 2363-2, April 1978.

8. Avco Everett Research Laboratory, Inc., "Parametric Study of Potential Early Commercial MHD Power Plants" Final Report, NASA/CR-159633, December 1979.
9. General Electric Co., "Parametric Study of Potential Early Commercial MHD Power Plants" Progress Reports, through December 1979.
10. P. Staiger and J. Abbott, "A Summary and Evaluation of PSPEC", Seventh International Conference on MHD Electrical Power Generation, Cambridge, Massachusetts, June 1980.
11. R. Ebeling and J. Cutting, "Oxygen-Enriched Air Production for MHD Applications, 18th Symposium on Engineering Aspects of MHD, Butte, Montana.
12. Westinghouse Electric Corporation, "A Safety Evaluation of A Reference Design for the MHD ETF" Final Report DOE/FE-2363-5, August 1979.
13. F. D. Retallick, et. al., "Preliminary Assessment of the Requirements and Potential of Open Cycle MHD as an Electric Utility Power Plant", 18th Symposium on Engineering Aspects of MHD, Butte, Montana.
14. "General Design Requirements, Engineering Test Facility (ETF), Office of MHD, DOE, Revision 0, January 4, 1980.

1. Report No. NASA TM-81499		2. Government Accession No.		3. Recipient's Catalog No.	
4. Title and Subtitle ENGINEERING TEST FACILITY DESIGN DEFINITION				5. Report Date	
				6. Performing Organization Code	
7. Author(s) R. W. Bercaw and G. R. Seikel				8. Performing Organization Report No. E-436	
9. Performing Organization Name and Address National Aeronautics and Space Administration Lewis Research Center Cleveland, Ohio 44135				10. Work Unit No.	
				11. Contract or Grant No.	
12. Sponsoring Agency Name and Address U. S. Department of Energy Magnetohydrodynamics Division Washington, D. C. 20545				13. Type of Report and Period Covered Technical Memorandum	
				14. Sponsoring Agency Code Report No. DOE/NASA/2674-11	
15. Supplementary Notes Prepared under Interagency Agreement EF-77-A-01-2674. Prepared for Seventh International Conference on Magnetohydrodynamic Electric Power Generation sponsored by the Symposium on the Engineering Aspects of Magnetohydrodynamics, Inc., Cambridge, Massachusetts, June 16-20.					
16. Abstract <p>The Engineering Test Facility (ETF) is the major focus of the Department of Energy (DOE) Magnetohydrodynamics (MHD) Program to facilitate commercialization and to demonstrate the commercial operability of MHD/steam electric power. The ETF will be a fully integrated commercial prototype MHD power plant with a nominal output of 200 MW_e. Performance of this plant is expected to meet or surpass existing utility standards for fuel, maintenance, and operating costs; plant availability; load following; safety; and durability. It is expected to meet all applicable environmental regulations. This paper describes the current design concept conforming to the general definition, the basis for its selection, and the process which will be followed in further defining and updating the conceptual design.</p>					
17. Key Words (Suggested by Author(s)) Magnetohydrodynamics; MHD; ETF; Electric power generation			18. Distribution Statement Unclassified - unlimited STAR Category 44 DOE Category UC-90g		
19. Security Classif. (of this report) Unclassified		20. Security Classif. (of this page) Unclassified		21. No. of Pages	
				22. Price*	

* For sale by the National Technical Information Service, Springfield, Virginia 22161